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ABSTRACT

The use of linear regression to identify variables that predict grades of black students in precalculus and calculus I was studied at Xavier University of Louisiana, a historically-black institution. The predictive power of the variables for black males and females was also assessed. These two mathematics courses are prerequisites for students wishing to study health fields. Entering freshman majoring in biology, chemistry, or pre-pharmacy in the fall semesters of 1981 and 1982 were studied. Of this population, 135 females and 81 males studying precalculus and 100 females and 64 males studying calculus I were evaluated. The following variables showed some potential for predicting grades in both precalculus and calculus at Xavier: high school grade point average (GPA), composite score on the American College Testing (ACT) program, vocabulary scores on the Nelson-Denny Reading Exam, and English and mathematics subsections of ACT. The ACT composite score was the single best predictor for precalculus, high school GPA was the best for all students taking calculus, and grade in precalculus was the best predictor of calculus. The variables predicted the grades of both sexes equally well, in contrast to other research that indicates that traditional criteria have more predictive power for black females than for black males. (SW)

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PREDICTORS OF FIRST-YEAR COLLEGE MATHEMATICS GRADES FOR BLACK AMERICANS

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PREDICTORS OF FIRST-YEAR COLLEGE MATHEMATICS GRADES FOR BLACK AMERICANS

Abstract : There is a national need to address the underrepresentation of blacks in the health professions since such underrepresentation contributes to the fact that black America receives below average health care. One factor which contributes greatly to the underrepresentation of blacks in health fields is relatively poor performance in mathematics and mathematics-related courses at the college level. The current investigation uses linear regression to identify variables which can be used to predict grades in precalculus and calculus I at Xavier University of Louisiana, a historically-black institution. This study and similar ones have been undertaken in order to improve advising/placement of students and provide direction in developing intervention strategies to help the underprepared.

PREDICTORS OF FIRST-YEAR COLLEGE MATHEMATICS GRADES FOR BLACK AMERICANS

Many students interested in health careers fail to achieve their career goals because of inability to complete mathematics courses or mathematics-based courses such as chemistry or physics. While this problem is of concern in any populace, it is particularly devastating to minority groups such as black Americans who are severely underrepresented in the health sciences because underpresentation impinges on the quality and availability of primary health care in black communities. For example, it has been found (Davis and Davidson, 1982) that "minority health providers, particularly physicians, are more likely to serve minority patients. Consequently

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the shortage of minority health practicioners has a direct negative effect on minority communities." The magnitude of the problem is illustrated by noting that although the census currently estimates the percentage of blacks in the nation's populace to be approximately 12% (U. S. Government Census Estimates, 1982), less than 2.5% of the nation's health professionals are black (Association of Minority Health Professions Schools, 1983). There is thus an urgent need to improve the preparation of blacks in mathematics as one step in the effort to increase black representation in the health professions thereby improving the health care provided black America.

If there is to be significant progress toward reaching the goal of increasing the number of black Americans in health fields, both predominantly black and majority institutions must be involved in the effort. The potential role of the predominantly black colleges is indicated by the fact that while they enrolled only 17% of black Americans in college in the late 1970's, they awarded 37% of the baccalaureate degrees received by blacks nationwide and more than 50% of such degrees in states where the traditionally black colleges are located (National Advisory Committee on Black Higher Education and Black Colleges and Universities, 1980). Of particular value in the effort to increase the access of blacks to health careers are studies of factors which impinge upon achievement of blacks in mathematics and science courses. This paper describes one such effort, a study of predictors f success of black Americans interested in the health professions in first-year mathematics at Xavier University of Louisiana, a small predominantly black institution in New Orleans. It is one of a number of studies at Xavier initiated to improve advising of students interested in the health professions and to provide

direction in developing intervention strategies to help those who are underprepared.

Overview

Xavier University of Louisiana (XU) is a Catholic, liberal arts institution requiring 56 semester-hours of history, art, philosophy, etc. for graduation. Although XU is a typical liberal arts institution in philosophy, it does not have the enrollment pattern of the typical liberal arts institution. Approximately 50% of the 1,600 (or so) full-time undergraduates at Xavier are in majors designed to lead into a health profession. The University places from 65 to 75 Blacks into health professions school yearly, is regularly #1 in the United States in placing black Americans into colleges of pharmacy, and is consistently one of the top five schools in the nation in placing blacks into medical school. Xavier is thus particularly appropriate for studies of the performance of blacks interested in the health professions in college-level mathematics courses.

All students interested in the health professions at Xavier must complete (or demonstrate competence in) a four semester-hour precalculus course and a four semester-hour overview of calculus. In addition, students with detectable deficiences in either arithmetic or beginning algebra must also complete a non-credit developmental course before enrolling in precalculus. Since the same level of competency on the same exam is needed to exit the developmental course as to bypass it, the developmental course serves merely to ensure that all students entering precalculus have a minimal level of arithmetic and algebraic skills. For that reason it is reasonable to study performance in precalculus and calculus I separately as in this investigation.

Class size in both precalculus and calculus I at Xavier is generally limited to 30-35 students. Students in both courses are required to purchase a traditional text and a locally-produced workbook consisting of short modules containing learning goals, specific homework/reading assignments, a list of alternative learning aids available, and sample exams. Both courses feature frequent testing (an hour exam roughly once every two weeks) and coordination so that all sections of the two courses give common exams on the same day written from prescribed formulas by the faculty as a team. The content of the precalculus course is the typical combination of algebra and trigonometry. Calculus I covers both differential and integral calculus with emphasis on the development of skills and the application of concepts. A Primer for Calculus (Holder, 1984) is currently used as the text in precalculus and Calculus--A Practical Introduction (Millman and Parker, 1979) is used in calculus I.

Previous studies have identified a number of predictors of grade in college-level mathematics. Clark (1982) found that a combination of performance on a locally-produced placement exam, high school grade point average, grades in high school mathematics, and grades in college prior to enrolling in calculus can be used to predict success in calculus. Similarly, Troutman (1977) found that SAT Mathematics score is a good predictor for success in finite mathematics and that adding high school rank and high school mathematics grade average improves the correlation coefficient to 0.611. Pugh et. al. (1969) obtained similar results in discovering that SAT Mathematics score and high school rank are the best predictors of success in college mathematics. The studies are not in complete agreement, however. Costello (1977) concluded that SAT mathematics scores, SAT verbal

scores, and total SAT are not related to student's performance in college mathematics in a study of effect of minimum SAT requirements for entry into engineering school. He therefore recommended reevaluaton of the use of the SAT for such screening purposes.

While of interest, none of the studies above directly address the current problem since none specifically consider the performance of black Americans in college-level mathematics. Of potential value are recent reviews of the status of blacks in mathematics at the precollege level (Johnson, 1984; Jones, Burton, & Davenport, 1984; Matthews, Carpenter, Lindquist, & Silver, 1984) and previous investigations of the performance of blacks in college in areas other than mathematics. Some of the latter (Stanley & Porter, 1967; Hills, 1964; McKelpin, 1965) indicate that traditional variables predict overall college grades of black students at predominantly black colleges reasonably well, and at least one study finds that there is a signifiant relationship between scores on the Nelson-Denny Reading Test and grades of black freshmen college students (Joyner, 1973). Also of interest are recent studies (Hunter, 1984; Carmichael, et. al., 1986; Carmichael, et. al., 1986) which indicate that a combination of ACT composite score and high school grade point average is a good predictor of success of blacks in first-year biology, first-year chemistry, and the overall prehealth curriculum here at Xavier. The trend of successful prediction for blacks does not seem valid in two areas, however. First, the traditional criteria predict the performance of black students at predominantly white institutions considerably less accurately than they predict the performance of white students at those same institutions (Borgen, 1972; Temp, 1971). Second, there is evidence that traditional criteria are less useful in

predicting the academic performance of black males than that of black females (Sample & Seymour, 1971; Farver, Sedlacek, & Brooks, 1973).

These studies lead to the questions for the present investigation.

(1) Can traditional variables predict performance of black Americans in precalculus/calculus at a traditionally black institution? If so, what is the predictive procedure?

(2) How does predictive power for black males vary from that for black females?

Procedure

The required mathematics sequence for students interested in the health sciences at XU is a two-semester sequence composed of precalculus (Mathematics 1030) and calculus I (Mathematics 1040). Ten readily available, traditional variables found to have predictive power in the studies cited above were chosen for study as potential predictors of grade in precalculus. They were...

...High school grade point average (GPA) on a 4.0 scale,

...Composite score on the American College Testing Program (ACT) and scores on the four subsections (mathematics, English, natural science, and social science) on the established 1 to 36 scale,

...Scores on the three portions of the Nelson-Denny Reading Test (vocabulary, comprehension, and total) in terms of grade level equivalents,

and ...sex of student.

The population under study consisted of students entering Xavier as freshmen and majoring in biology, chemistry, or prepharmacy in the fall semesters of 1981 and 1982. Of these students, 216 (135 females and 81 males), approximately 60% of the students entering XU in such fields in those years, were used in the study of precalculus. 164 of

the group (100 females and 64 males) enrolled in calculus I. 128 (78 females and 50 males) did so after taking precalculus at Xavier and 36 (22 females and 14 males) went directly into calculus I. Students in all three prehealth majors are scheduled to the required mathematics sequence during either the freshman or sophomore year and the large majority of the students in the study took it during one of those years. Although some students repeat one or more of the required courses, the grade from the first attempt was used in this study. The remainder of the students entering Xavier in those years were excluded from the study from this study because they did not present ACT scores when applying to the University or dropped from the "prehealth" majors under study before enrolling in precalculus.

Predictors of Grades in Mathematics 1030 and 1040

Analyses were performed using the Statistical Package for the Social Sciences (SPSS)--Version 9. First, means and standard deviations were obtained for all variables associated with Mathematics 1030 and 1040. Numerical values were substituted for the alphabetical values of Mathematics 1030 and 1040 grades (A=4, B=3, C=2, D=1, and W or F=0) and a dummy variable was introduced for sex (Male=1 and Female =0). The grade in Mathematics 1030 was added to the list of Mathematics 1040 predictive variables for the 128 students who had taken that course. Results are summarized in Table 1.

Table 1--Means and Standard Deviations of Predictors for Students in Mathematics 1030 (Precalculus) and 1040 (Calculus I)

Variable	Math 1030 (N = 216)		Math 1040 (N = 164)		Math 1040 (N = 128)	
	Mean	Stand Dev.	Mean	Stand. Dev.	Mean	Stand. Dev.
Math 1040 Grade	----	----	1.49	1.45	1.30	1.39
Math 1030 Grade	1.59	1.25	----	----	2.18	1.08
High School GPA	2.83	0.59	2.98	0.60	2.93	0.60
ACT Composite	16.5	4.45	18.1	4.79	17.7	4.33
ACT English	15.0	6.06	17.6	6.14	16.9	5.51
ACT Mathematics	16.9	4.69	18.1	4.99	17.7	4.78
ACT Natural Science	18.4	5.41	19.8	5.51	19.2	5.34
ACT Social Science	15.0	6.17	16.2	6.51	16.1	6.17
Nelson-Denny Vocabulary	12.5	2.55	13.0	2.43	13.0	2.34
Nelson-Denny Comprehension	12.9	2.58	13.3	2.49	13.2	2.49
Nelson-Denny Total	12.7	2.35	13.2	2.38	13.2	2.24
Sex	0.375	0.48	0.390	0.49	0.391	0.49

The 16.0 mean of the ACT Composite scores for students in Mathematics 1030 is slightly below the 17+ mean of freshman in the Southwest and South/Southeast (American College Testing Service, 1983) and reading scores are slightly below the expected 13th grade level. The mean for sex (0.37) reflects the fact that approximately one-third of the students were male, a distribution by sex that is typical of the enrollments in general in mathematics at XU and of the University as a whole. The slight increase in the dummy sex variable from Mathematics 1030 to Mathematics 1040 reflects slightly higher attrition of females than of males. The increase in the means of the academically related variables is not surprising, since normal academic selection would be expected to eliminate more of those with lower scores.

Next, Pearson correlation coefficients between the Mathematics 1030 and 1040 grades and each of the potential predictor variables were calculated. These correlations are presented in Table 2.

Table 2--Correlation Coefficients (r) Between Math 1030 and Math 1040 Grades and Each of the Independent Variables

Independent Variable	r with Math 1030	r with Math 1040 (Total N=164)	r with Math 1040 (Precalculus N=128)
Mathematics 1030 Grade	-----	-----	0.551
High School GPA	0.455	0.472	0.495
ACT Composite	0.515	0.356	0.448
ACT English	0.508	0.377	0.383
ACT Mathematics	0.405	0.265	0.383
ACT Natural Science	0.366	0.271	0.343
ACT Social Science	0.399	0.265	0.335
Nelson-Denny Vocabulary	0.413	0.312	0.444
Nelson-Denny Comprehension	0.291	0.165	0.291
Nelson-Denny Total	0.381	0.256	0.404
Sex	-0.105	-0.014	-0.148

The correlation coefficients for high school grade point average, ACT composite, ACT English, ACT Mathematics, and Nelson-Denny Vocabulary scores are sufficiently large to indicate that those variables have use in predicting grades in Mathematics 1030, with ACT Composite score being the best single predictor. Approximately 26% of the variance (r^2 x 100) in Mathematics 1030 grade can be explained by variance in ACT Composite score.

The data for Mathematics 1040 show that the best single predictor for grade in Mathematics 1040 for the total group of 164 is high school grade point average. For that subgroup who also took precalculus, grade in precalculus is the best single predictor but ACT Composite score, high school grade point average, and some of the other variables also have considerable predictive power.

Multiple linear regressions were completed for both Mathematics 1030 and 1040. Variables were added one at a time so as to obtain the maximum increase in the multiple correlation coefficient R at each step, until adding more terms failed to produce a statistically

signicant improvement at the 0.05 level. Before performing this analysis, the components of the ACT and of the Nelson-Denny Reading Test were dropped from consideration. The high degree of correlation between the composites and their respective components indicated that composites and components were so interdependent that regression procedures would not be applicable if both were included. Subsequent multiple linear regression analyses using components rather than composites verified that use of components did not improve predictive power. The results of linear regressions with high school grade point average, ACT Composite, Nelson-Denny Reading Total, sex, and Mathematics 1030 grade (when applicable) as possible predictive variables are summarized in Table 3. The final column in that table indicates the probability (p) that the observed relationship occurred by chance.

Table 3--Summary of the Stepwise Multivariate Linear Regression Analysis

For Mathematics 1030

Step	Variable Added	R	R^2 x100	ΔR^2 x100	p
1	ACT Composite	0.515	26.5%	---	<0.001
2	High School GPA	0.597	35.6%	9.1%	<0.001

For Mathematics 1040--All 164 Students

Step	Variable Added	R	R^2 x100	ΔR^2 x100	p
1	High School GPA	0.472	22.3%	---	<0.001
2	ACT Composite	0.507	25.7%	3.4%	<0.001

For Mathematics 1040--128 Who Took Mathematics 1030

Step	Variable Added	R	R^2 x 100	ΔR^2 x 100	p
1	Math 1030 Grade	0.551	30.4%	---	<0.001

For Mathematics 1030, adding high school grade point average to ACT Composite increases R from 0.515 to 0.597 while variance in grade explained increases by 9.1%, to 35.6% of the total. The remaining variables did not produce a statistically significant increase (at the .05 level) in predictive ability when added. The unstandardized predictive equation for Mathematics 1030 was found to be

$$Y = 0.115(X1) + 0.678(X2) - 2.22$$

where Y = Predicted Mathematics 1030 grade with A =4, B=3, C=2, D=1, and W or F = 0
X1 = ACT composite score
X2 = High school grade point average

For all 164 students who took calculus I, linear regression indicates that a high school grade point average is the best predictor of calculus I grade (R =0.472) and that adding ACT Composite increases R to 0.507 after which the addition of other variables do not make statistically significant improvement in R . This linear

regression yielded the following unstandardized predictive equation:

$$Y = 0.959(X1) + 0.061(X2) - 2.47$$

where Y = Predicted Mathematics 1040 grade on a "4 to 0" scale as indicated above
X1 = High School Grade Point Average
X2 = ACT Composite Score

For the 128 students who took precalculus before taking calculus I, the best single predictor of calculus I grade was precalculus grade ($\underline{R}$ =0.551) and no other predictor variable under consideration increased predictability in a statistically significant manner. The unstandardized predictive equation for this group was:

$$Y = 0.706(X1) - 0.243$$

where Y = Mathematics 1040 grade on a "4 to 0" scale
X1 = Mathematics 1030 grade on the same scale

Next, since previous investigations have indicated that traditional criteria were less useful in predicting the academic performance of black males than of black females (Samples & Seymour, 1971; Farver, Sedlacek, & Brooks, 1973), separate multiple regression analyses were run for each. In Mathematics 1030, ACT Composite was the best predictor for both sexes, yielding $\underline{R}$ = 0.541 for females and $\underline{R}$ = 0.459 for males. Subsequent addition of high school grade point average in a second step increased $\underline{R}$ to 0.617 for females and 0.545 for males. Addition of other variables made no statistically significant improvement in $\underline{R}$ in either case. For Mathematics 1040 with all 164 students, high school grade point average was the best predictive variable for both sexes when considered separately and no other variable made statistically significant improvement in $\underline{R}$. The multiple correlation coefficients for high school grade point average and Mathematics 1040 grade for this group was 0.480 for females and

0.497 for males. For the 128 students who took Mathematics 1030, grade in Mathematics 1030 was the single best predictor of Mathematics 1040 grade for both sexes and no other variables entered into the equation. The R values for females and males were 0.548 and 0.568, respectively.

Discussion

The following conclusions were drawn in light of the statistical results and previously published work.

(1) Can traditional variables predict performance of black Americans interested in the health professions in first-year mathematics at a traditionally black institution? If so, what is the predictive procedure?

Table 1 indicates that high school grade point average (GPA), ACT composite score, score on the vocabulary portion of the Nelson-Denny Reading Exam, scores on the English and Mathematics subsections of the ACT all have some potential for predicting grades in both precalculus and calculus at Xavier. The ACT composite score is the single best predictor (r =0.515) for precalculus, high school grade point average is the best for all students taking calculus (r =0.472), and grade in precalculus is the best predictor of calculus grade (r =0.551) for that subgroup who also took precalculus. It should be noted that the correlation coefficient between high school grade point average is also high for this subgroup, r = 0.495.

It was noted that a number of the predictor variables had higher correlation with performance in precalculus and calculus than score on the Mathematics subsection of the ACT. Further, the ACT Mathematics subsection also did not appear in the predictive equations when components rather than composite were used in the linear regressions.

This finding is in agreement with Costello (1977) who questioned the value of using SAT Mathematics score to predict first-year college mathematics grades and in contrast to those (Troutman, 1977; Pugh, et. al., 1969) who found that the Mathematics subsection on the SAT had relatively good predictive value for grades in such courses.

The full regression analysis in the current study indicates that a combination of ACT Composite score and high school grade point average yields the best predictive equation for grade in precalculus with an R of 0.597. Similarly, it is found that combination of high school grade point average and ACT Composite score yields the best prediction of grade in calculus when all students are included (R =0.507) and that grade in precalculus alone enters into the predictive equation for that subset of students who took precalculus (R =0.551). All of the R values obtained are sufficiently large to indicate the predictive equations are useful.

Case by case comparison of actual grade with predicted grade (rounded off to the nearest grade) showed that the equation for Mathematics 1030 predicted grades correctly 32% of the time and was in error by only one letter grade an additional 51% of the time. The equation for all students in Mathematics 1040 predicted grades correctly for 32% of the students and was in error by one letter grade for an additional 53%. The equation for prediction of grade in Mathematics 1040 for the subset who took precalculus was correct 49% of the time and in error by one letter grade for an additional 33%.

(2) How does predictive power for black males vary from that of black females?

The variables considered predict the grades of black males in

both precalculus and calculus at Xavier approxmately as well as they do the grades of black females. Separate multiple linear regressions for males and females yielded similar R values for both Mathematics 1030 and Mathematics 1040. These findings are in contrast to previous studies elsewhere, which indicated that traditional criteria have considerably more predictive power for black females than for black males (Sample & Seymour, 1971; Farver, Sedlacek, & Brooks, 1973), but in agreement with studies of first-year biology, first-year chemistry, and success in the overall prehealth curriculum here at Xavier (Hunter, 1984; Carmichael, et. al, 1986; Carmichael, et. al., 1986).

In conclusion, previous investigations show that procedures like those used in this study are successful in predicting the academic performance of majority students at majority institutions, in mathematics as well as in other areas. The current study shows that the same is true for black students in mathematics at a predominantly-black institution. The study is thus in agreement with results which show that a combination of ACT Composite score and high school grade point average is a relatively good predictor of grade in first-year biology and chemistry at Xavier (Hunter, 1984; Carmichael, et. al., 1986) as well as overall success in the first two years in the prehealth professions curriculum here (Carmichael, et. al., 1986). The question of why these measures fail for minority students at majority institutions, and occasionally at other times, is of some importance, both to those interested in the interpretation of studies of this type, and to those concerned with the specific academic difficulties experienced by minorities.

The authors propose, given the results of numerous studies of this type cited above, that high values of R (.45 or above) are to be

expected when predicting grade with traditional indicators. Predictor studies may then serve as a warning system. R values lower than expected could indicate that a noncognitive factor, possibly a cultural one, is interfering with the academic process. If so, predictor studies could provide direction as individual schools seek to improve minority performance in their mathematics and science programs. If predictor studies yield high R values, it is likely that emphasizing academic skills will yield the greatest improvement. If, on the other hand, R values are low, perhaps equal emphasis should be placed on developing support systems which attempt to deal with and, where possible, overcome the interfering non-cognitive factors. Research is needed to identify the specific non-cognitive factors which lead to the failure of traditional academic indicators on individual campuses, so that support strategies can be tailored to local conditions.

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